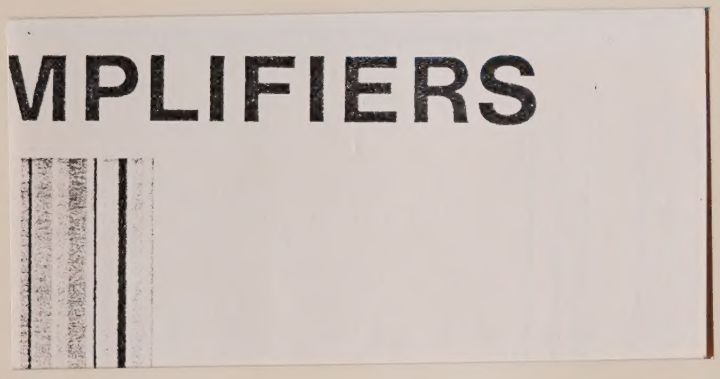
INSTRUCTION
MANUAL

AILTECH



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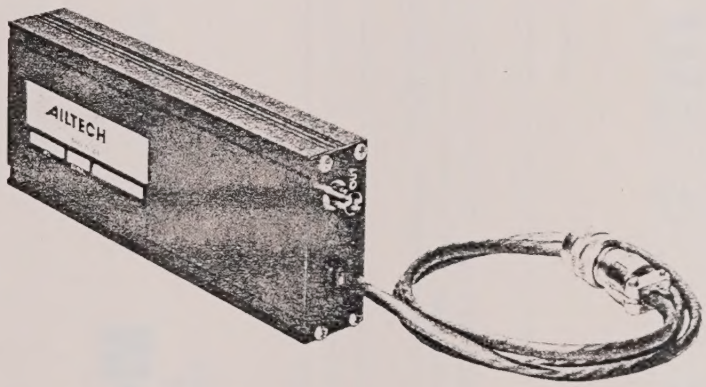
Eaton Corporation
Electronic Instrumentation Division
Los Angeles, California 90066

INSTRUCTION MANUAL FOR

AILTECH 13680/13681

PREAMPLIFIERS



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Electrical and Electronic Measuring Instruments .....1 Year

Repair or replacement (at our option) without charge (F.O.B. factory) will be effected when our examination satisfactorily indicates that defects are due to workmanship or materials. Electron tubes, semiconductors, batteries, fuses, lamps, thermoelements, and Ratio Tran potentiometers are excluded from warranty coverage. Warranty returns must first be authorized by the factory.

If the instrument or any portion thereof, has been abused, misused, damaged by accident or negligence, or if any serial number or seal has been removed or altered, the warranty is void.

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Chargeable repairs: If requested, an estimate of charges will be made prior to repairs. Please provide us with the following information in order to expedite the processing of your instrument:

1. Model or Type
2. Serial Number
3. Description of trouble(1)
4. Approximate date instrument was placed in operation.
5. Approximate number of hours in use.
6. Maintenance action previously requested or performed.
7. Other comments.

(1) Include data on symptoms, measurements taken, suspected location of trouble, maintenance action taken and any other relevant data.

APRIL 1979

OPERATION OF THE AILTECH 135 SERIES MIXERS

I. The 135 Series Mixers are designed to plug-in and operate with the AILTECH 136 Series Preamplifiers. The I.F. outputs are via pins which mate with spring clips at the Preamplifier inputs. Because of this, they must be operated in conjunction with a 13630, 13650, 13680, or 13681.

Since these devices are accessories to our instrument line, used to downconvert RF and microwave frequencies to the 30 MHz intermediate frequency of the preamplifiers, applicable specifications consist only of their individual frequency ranges (listed in the Noise Instrumentation Catalog).

II. Three types of mixers are represented in the 135 Series:

A. At lower frequencies (below 2 GHz), the mixers are of the doubly-balanced configuration utilizing four diodes in a bridge configuration. These are identifiable by the fact that they have only one output pin.

B. Between 2 GHz and 11 GHz, the mixers are of the coaxial, hybrid, double-ended, unbalanced configuration utilizing two diodes one of which is reversed, so that the I.F. signals at the two output pins are in phase.

C. Above 8.2 GHz, most mixers are in a waveguide ortho-tee configuration, and are also double-ended, unbalanced.

The following list identifies the three types by part number.

FREQUENCY RANGE	P/N	TYPE*	LO/RF CONNECTORS
0.01 - 1 GHz	13508	A	TNC
1 - 2 GHz	13504	A	TNC
2 - 4 GHz	13505	B	N
3.6 - 4.2 GHz	13509	B	N
4 - 8 GHz	13506	B	N
7 - 11 GHz	13507	B	N
8.2 - 12.4 GHz	13546	C	WR-90 Cover flange
12.4 - 18 GHz	13547	C	WR-62 Cover flange
18 - 26.5 GHz	13553	C	WR-42 Cover flange
26.5 - 38 GHz	13596	C	WR-28 Cover flange

*Reference preceeding paragraphs.

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III. The mixers are designed to bolt on to the front end of a 136 Series Preamplifier (mounting hardware is provided with the Preamplifier). Power is provided to the Preamplifier via an integral cable by a 13610 Precision Test Receiver, 75 PANFI or an appropriate external power supply (pin connections for the Preamplifier are detailed in the 13610 Instruction Manual).

Local oscillator power is applied to the L.O. port of Type A mixers or to either port of Types B and C. The 13610 Receiver provides a means of monitoring L.O. drive of Types B and C mixers by means of a meter readout of rectified crystal current. The nominal crystal current of Types B and C is 1 mA in each crystal. Typically, this requires between 0 and +3 dBm of L.O. drive (1 to 2 mw).

In some mixers (Types B and C) it may not be possible to achieve exactly 1 mA in both crystals simultaneously. This is due to external mismatch, internal reflections, etc. A three-to-one ratio of currents is considered acceptable; i.e., one crystal operating at 0.5 mA, the other at 1.5 mA. These mixers should never be operated at greater than 3 mA crystal current.

If the balance condition above cannot be met, it is usually due to one of two conditions:

A. A poor VSWR at one or both input ports (both ports must be terminated properly).

B. A bad crystal (Reference AEB 135-1 for a listing of replacement crystals).

There is no provision for monitoring crystal current in Types B and C mixers when the AILTECH 75 PANFI is used as the power source for the Preamplifier; however, external voltmeters can be used for this purpose. Pins 5 and 6 on the Preamplifier power connector provide voltages proportional to crystal current (100 mV per mA). Pin 3 is the return.

The crystal returns in Type A mixers is internal to the mixer, and no crystal current will be observed on a 13610 or external meter. These mixers should be driven at about +7 dBm L.O. power (5 mw). The L.O. drive is not critical and may be adjusted for best mixer performance (noise figure, for example). The drive should, however, not exceed +10 dBm.

William E. Pastori

William E. Pastori, Product Line Manager, Noise Products

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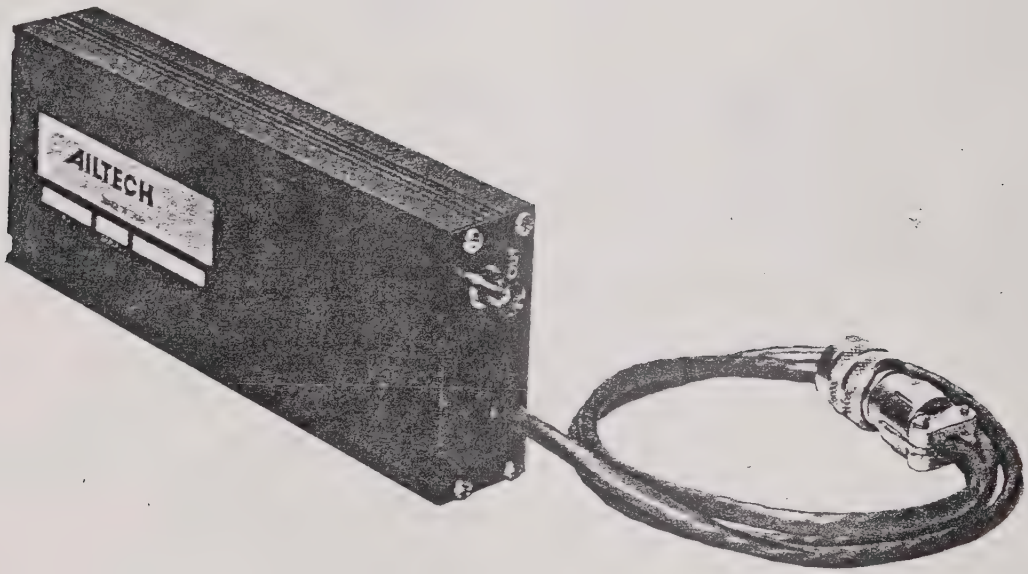


FIGURE 1-1. AILTECH 13680/13681 PREAMPLIFIER

CHAPTER I

GENERAL

1-1. INTRODUCTION

1-2. This manual contains installation, operation and maintenance instructions, technical data, and applications information for the AILTECH 13680 Low Noise Preamplifier, and the 13681 Wide Range Preamplifier.

1-3. GENERAL DESCRIPTION

1-4. The AILTECH 13680/81 Preamplifiers, Figure 1-1, are 30 MHz tuned amplifiers. They are generally used in noise figure or attenuation setups incorporating the AILTECH 75 Precision Automatic Noise Figure Indicator (PANFI), or the AILTECH 136 Precision Test Receiver (PTR). The Preamplifiers can be used independently of the PANFI and the PTR with an appropriate external power supply.

1-5. Both Preamplifiers require an accessory Input Unit which bolts to the Preamplifier front end. Input Units are described in Section 1-9. The choice of Input Unit depends upon the application. Typical examples are provided in later sections.

1-6. TECHNICAL SPECIFICATIONS

1-7. Low Noise Preamplifier, P/N 13680

Center frequency	30 MHz
IF noise figure	3.3 dB nominal
Gain	45 dB minimum

Bandwidth	3 MHz minimum
Maximum linear output power	+17 dBm for 0.1 dB compression
Maximum output power	+27 dBm (50-ohm load)
Power requirement	+20 V at 250 mA nominal
Size (excluding mixers, adapters and connectors)	8-1/2 x 3-1/4 x 1-1/2 in. (21.1 x 6.3 x 3.8 cm)
Weight	17 ounces (0.48 kg)

1-8. Wide Range Preamplifier, P/N 13681

Center frequency	30 MHz
IF noise figure	6 dB nominal
Gain	30 dB minimum
Bandwidth	3 MHz minumum
Maximum linear output power	+17 dBm for 0.1 dB compression
Maximum output power	+27 dBm (50-ohm load)
Power requirement	+20 V dc at 225 mA nominal
Size (excluding mixers, adapters and connectors)	8-1/2 x 3-1/4 x 1-1/2 in. (21.1 x 6.3 x 3.8 cm)
Weight	17 ounces (0.48 kg)

1-9. INPUT UNITS

1-10. The AILTECH 13680/81 Preamplifiers require the use of an Input Unit for operation. These units bolt to the front of the Preamplifiers. Connections are made by output pins on the Input Units and mating compression spring clips at the inputs of the Preamplifiers.

1-11. 50 Ohm Impedance Adapter, P/N 208393

1-12. This adapter is designed to transform a 50 ohm source impedance into the nominal, optimum source impedance required for minimum Preamplifier noise figure. Note that the Adapter input impedance, when connected to a Preamplifier, is not 50 ohms.

1-13. The 208393 is a rectangular, extruded, sheet metal enclosure, open at one end. A single output pin mates with one of the input clips on the Preamplifiers.

1-14. This Adapter enables the Preamplifiers to be used as a simple 30 MHz amplifier to increase the sensitivity of a 50 ohm measurement system. A typical application would be as the first IF amplifier following a mixer exhibiting a 50 ohm IF output impedance.

1-15. 150 Ohm, 20 pF, Impedance Adapter, P/N 208550

1-16. The 208550 Adapter is similar to the 208393 except that it is designed to transform a source impedance of 150 ohms shunted by 20 pF, into the nominal optimum source impedance required by the Preamplifiers for minimum noise figure.

1-17. The 208550 Adapter is mechanically similar to the 208393 except that the input is via a length of cable terminated by a BNC male connector. This cable is part of the transformation network, and should not be removed.

1-18. This Adapter is generally used when the Preamplifiers follow a double-ended, unbalanced mixer. The typical IF output impedance of such mixers is 150 ohms resistive in parallel with 20 pF capacitance.

1-19. Frequency Converter, 40 to 150 MHz, P/N 13635

1-20. The AILTECH 13635 Converter enables the Preamplifiers to be used in test systems operating from 40 to 150 MHz. It consists of an unpreselected mixer driven by a local oscillator, whose frequency is continuously variable, followed by a low-pass filter.

1-21. Frequency control is by means of an uncalibrated knob extending from the front of the sheet metal enclosure. The input connector is a Type N female on the side of the case.

1-22. R.F. Mixers, 135 Series

1-23. Table 1-1 below lists a series of mixers designed to plug-in and bolt to the Preamplifiers' inputs. All require external local oscillator power as indicated. These mixers permit the Preamplifiers to be used in test systems operating between 10 MHz and 38 GHz.

TABLE 1-1

AILTECH 135 SERIES MIXERS

P/N	Frequency Range (GHz)	Local Oscillator Power (Nominal) (dBm)	Crystal Current (mA)	Input Connectors
13504	1.0 - 2.0	+7	N/A*	TNC Female
13505	2.0 - 4.0	+3	1	N Female
13506	4.0 - 8.0	+3	1	N Female
13507	7.0 - 11.0	+3	1	N Female
13508	0.01 - 1.0	+7	N/A*	TNC Female
13509	3.6 - 4.2	+3	1	N Female
13546	8.2 - 12.4	+3	1	WR-90 Cover Flange
13547	12.4 - 18.0	+3	1	WR-62 Cover Flange
13553	18.0 - 26.5	+3	1	WR-42 Cover Flange
13596	26.5 - 38.0	+3	1	WR-28 Cover Flange

*Double-balanced configuration - crystal current return internal.

CHAPTER II

INSTALLATION

2-1. INTRODUCTION

2-2. This chapter describes unpacking, inspection, and preparation for use of the AILTECH 13680/13681 Preamplifiers.

2-3. UNPACKING, INSPECTION, AND DAMAGE CLAIMS

2-4. No special instructions or precautions are necessary for unpacking the Preamplifier; the unit is ready for use immediately upon receipt. The following checks should be made to assure that no damage has occurred during shipment.

a. Inspect the shipping container prior to acceptance from the carrier. Note any damage to the shipping container on the carrier's receipt.

b. Inspect the unit for damage. Check for dents, scratches, broken connectors, etc.

c. If damage is not apparent until after the instrument has been accepted, file a claim for concealed damage with the carrier within 15 days after receipt. All packaging material must be forwarded to Eaton Corporation, Electronic Instrumentation Division.

2-5. ANCILLARY ITEMS

2-6. Each Preamplifier is shipped with one copy of the Instruction Manual, and four screws for mounting a Converter (13635) or 135 Series Mixer to the input (special extra-length screws are required for mounting Impedance Adapters - these are provided with the Adapters). Before discarding the shipping container, make certain these items are removed.

2-7. PREPARATION FOR USE

2-8. Once an Input Unit is mated to the Preamplifier input, and the multi-conductor cable (integral to the Preamplifier and exiting from the rear of the case) connected to an appropriate power source, the instrument is ready for use.

2-9. The input clips on the Preamplifier, designed to mate with Input Unit output pins, are deliberately offset vertically. This is to insure proper orientation of the Input Units. If an Input Unit is inadvertantly mounted upside down, there will be a gap between the mating surfaces and the Unit should be inverted. The mating configuration is such that the Input Unit output pins should be above the mounting surface center line.

2-10. Some Input Units have only a single output pin; however, the same considerations noted above still hold. The 13635 Converter has two connections at the mating surface. One of these, the signal output connection, is offset vertically, and, as above, mates with a Preamplifier input clip above the center line. The other, the local oscillator power connection, must be mated with the spring clip on the underside of Preamplifier printed circuit board.

2-11. POWER SUPPLY CONNECTIONS

2-12. The 136-Series Preamplifiers are designed for operation with the AILTECH 75 Precision Automatic Noise Figure Indicator (PANFI), the AILTECH 13610 and the 13611 Precision Test Receivers (PTR). The Preamplifiers are connected to the test instruments by an integral multi-conductor cable with a push-on power connector. The mating connector for the AILTECH 75 PANFI is located on its rear panel, and is labeled "Preamp Power". The connector for the AILTECH 136 PTR's is located on the front panel of the instruments and is also labeled "Preamp Power".

2-13. The AILTECH 13611 Precision Test Receiver uses a different power connector than earlier 75 PANFI's and 13610 PTR's, and an adapter cable, supplied with the Receiver, is required.

2-14. The 13680 and 13681 require +20 volts for proper operation. Some earlier Test Receivers and PANFI's require the addition of a +20 volt line to the power connector.

2-15. To operate the 13680 or 13681 with an AILTECH 7511 or 7512 PANFI (serial numbers less than 3001):

Connect terminal 5 of the main chassis power supply (P/N 212967) to pin 2 of the Preamplifier power plug on the rear panel with a short length of wire.

2-16. To operate the 13680 or 13681 with an AILTECH 13610 (serial numbers less than 1901):

An additional hole for a power feed-through filter is added to the Preamplifier power connector filter case behind the front panel. A wire goes from pin 2 of the Preamplifier power connector to the added feed-through filter. The outside terminal of this filter is connected with a length of wire to a 12-watt, 82 ohm, Ohmite power resistor which is added to the main chassis. Connect terminal 6 of the main chassis power supply (P/N 207930) to the remaining terminal on the Ohmite power resistor.

Parts are available for the above conversions from Eaton Corporation at a nominal charge. Order as follows:

P/N 3776	Res., 12 watt, 82 ohm	Qty. 1 ea.
P/N 54-804-002-102P	Filter, Feed-through	Qty. 1 ea.
P/N 0603-13-2056	Connector pin	Qty. 1 ea.

2-17. The 13680 and 13681 Preamplifiers may be operated from an external power supply independent of either a PANFI or PTR. The power supply must be capable of providing +20 volts DC at 250 mA minimum.

2-18. The mating connector for the Preamplifier power plug is:

Deutsch Connector Corp. P/N 754-7-OSN

This connector is available, at nominal cost, from Eaton Corporation in limited quantities, or may be ordered directly from the original manufacturer.

2-19. To operate either Preamplifier from an external power supply:

Connect +20 volts DC to pin 2 of the mating connector. Connect the negative side of the power supply (ground) to pin 1 of the mating connector.

2-20. MIXER CRYSTAL CURRENT MONITOR

2-21. Several AILTECH 135 Series Mixers require that the local oscillator drive be adjusted to produce a nominal mixer crystal current. Specific mixers requiring this type of operation are noted in Table 1-1. Additional information on operation of Series 135 Mixers can also be found in Application Engineering Bulletins 135-1 and 135-2, included in the rear of this manual.

2-22. The AILTECH 13610 and 13611 Precision Test Receivers provide crystal current indications directly on the front panel; however, when operating from a 75 PANFI, or from an external power supply, this function, if required, must be provided by the user.

2-23. The crystal current returns for the 135 Series Mixers are internal to the Preamplifiers through 100-ohm, 1% resistors. Connections to the resistors are brought out to the power plug. A DC voltmeter can, therefore, be used to monitor crystal current with a conversion factor of 100 mV per mA of current. Pin connections on the power plug are:

Crystal #1	Pin 6
Crystal #2	Pin 5
Crystal return	Pin 3

2-24. One crystal in each of these mixers is of the reversed polarity type; thus it will be necessary to reverse the meter polarity when switching from one monitor connection to the other in order to obtain an up-scale reading.

CHAPTER III

OPERATING INSTRUCTIONS

3-1. GENERAL

3-2. The AILTECH 136 Preamplifiers are relatively simple devices with no external controls or indicators. They provide a fixed gain at 30 MHz. The actual amount of gain, and the noise performance of the Preamplifier are primarily functions of the Input Unit utilized.

3-3. Operation and application is generally determined by intended use; e.g., noise figure measurement, attenuation calibration, etc. Specific instructions for these applications are adequately covered in detail in the Instruction Manuals for the major instruments (136 Receivers and 75 PANFI). This Chapter, therefore, will be limited to general operating precautions in primary applications.

3-4. NOISE FIGURE MEASUREMENTS WITH THE 75 PANFI

3-5. In general, a 136 Preamplifier is used in conjunction with a PANFI when:

a. The noise output level of the unit under test (UUT) is less than -76 dBm (the 30 MHz low-level limit for proper operation of the PANFI).

b. The output frequency of the UUT is between 1 and 38 GHz*.

*NOTE: Options applicable to the PANFI are available, with appropriate necessary filtering, to cover the 10 to 1000 MHz frequency range.

3-6. The 13680 Low-Noise Preamplifier is the normal choice for very low-level applications, whether the system operates at 30 MHz or some microwave frequency. It provides the lower noise figure and exhibits a +17 dBm, 0.1 dB compression point. When used with an Impedance Adapter (see Section 1-11 and 1-15), the measurement range of the PANFI/Preamplifier combination is approximately -106 dBm (the Preamplifier effective input noise level) to -56 dBm (the upper limit of the PANFI range with 45 dB Preamplifier gain).

3-7. These figures are typical, and are based on the Preamplifier, with 3 MHz bandwidth, being the most narrow-band device in the measurement system. If a 135 Series Mixer is used as the Input Unit, both the upper and lower limit increase by the typical conversion loss and noise figure exhibited by the mixers. These will generally range from 6 to 18 dB depending upon frequency, mixer configuration (waveguide or coaxial) and local oscillator type (cavity oscillator, sweep generator, synthesizer, etc.).

3-8. The 13681 Preamplifier is the more versatile choice for use with the PANFI. The low level limit with the PANFI will be about -103 dBm. The upper limit, however, will be about -41 dBm. The same considerations regarding the 135 Series Mixers noted in paragraph 3-7 apply.

3-9. The measurement levels quoted in the above paragraphs are approximate, as they are based on some assumptions. Appendix A to this Manual details the means by which these levels are calculated.

3-10. It should also be noted that the low end of the quoted measurement range is at the internal input noise level of the Preamplifier. If the gain-noise figure product of the UUT is very low and near the quoted levels, consideration must be given to the effect of Preamplifier noise figure on the overall measured noise figure (second-stage noise figure effects). The following equations provide the necessary correction factors for most typical measurement setups. In these equations:

F_m = measured noise figure

Subscripts refer to the first or second stage.
Superscripts refer to image or signal sideband.
All quantities are expressed as dimensionless ratios, not in dB.

a. For a single frequency measurement system (also an RF amplifier followed by a perfect, image-reject mixer - IF preamplifier)

$$F_m = F_1 + \frac{F_2 - 1}{G_1} \tag{3-1}$$

and, the measurement error is

$$E = \frac{F_1}{F_m} = 1 - \frac{F_2 - 1}{G_1} \tag{3-2}$$

b. For a narrow-band RF amplifier followed by a mixer-IF preamplifier that converts both sidebands with equal conversion gain (gain of the UUT at the image frequency is zero).

$$F_m = F_1 + \frac{2(F_2 - 1)}{G_1} \tag{3-3}$$

$$E = 1 - \frac{2(F_2 - 1)}{G_1} \tag{3-4}$$

c. For a broadband amplifier followed by a mixer-IF preamplifier that converts both sidebands with equal conversion gain

$$F_m = F_1 + \frac{2(F_2 - 1)}{G_1^s + G_1^i} \tag{3-5}$$

$$E = 1 - \frac{2(F_2 - 1)}{G_1^s + G_1^i} \tag{3-6}$$

3-11. Note that in (3-3) through (3-6) F_2 is what is normally referred to as the mixer "double-sideband" noise figure, and, in (3-5) and (3-6), F_1 is also a double-sideband noise figure.

3-12. NOISE FIGURE MEASUREMENTS WITH A 136 PRECISION TEST RECEIVER

3-13. The AILTECH 136 PTR utilizes a Precision Attenuator for manual Y-factor measurements, from which noise figure is calculated. In the normal setup, the Attenuator input is connected to the Preamplifier output; therefore, the upper limit of the measurement range is limited by the maximum linear input signal level to the Input Unit/Preamplifier combination.

3-14. The levels calculated for noise measurements are average power levels; however, random noise exhibits peaks which can significantly exceed the average level. In order to insure reasonable linearity with noise signals, a safety factor of 10 dB is normally applied to the 0.1 dB compression point; thus, the average power output level of the 13680 and 13681 Preamplifiers should be limited to +7 dBm. Input levels, therefore, should be limited to:

13680	-38 dBm
13681	-23 dBm

3-15. The AILTECH 136 PTR has a sensitivity (signal level required for an on-scale meter deflection) of about -70 dBm including the insertion loss of the Attenuator, when set to 0 dB indication. The minimum signal levels at the Preamplifier inputs are:

13680	-100 dBm (internal noise level in a 1 MHz bandwidth)
13681	-100 dBm

When the Input Unit is a 13635 Converter or a 135 Series Mixer, these levels should be increased by the conversion loss of the Input Unit (typically, 6 to 18 dB).

3-16. ATTENUATION AND GAIN MEASUREMENTS

3-17. In a typical attenuation measurement setup, the Preamplifier is located just ahead of the Precision Attenuator used as a calibration standard. This requires the Preamplifier to be linear over the expected range of signal levels for accurate measurements.

3-18. The lower limit of the measurement range is set by the apparent non-linearity caused by the inherent noise level of the Input Unit/Preamplifier combination. This effect can be held to less than 0.2 dB (non-linearity) if the signal level is more than

20 dB above the noise level.

3-19. The Input Unit/Preamplifier noise level can be determined by algebraically adding the noise figure to the standard reference noise in a 1 MHz bandwidth, -114 dBm (assumes the measuring instrument, such as an AILTECH 136 PTR, has a nominal, 1 MHz bandwidth). As an example, if a 135 Series Mixer/136 Preamplifier combination exhibits a 14-dB noise figure, then the low end of the measurement range, for less than 0.2 dB non-linearity error is:

$$-114 + 14 + 20 = -80 \text{ dBm}$$

3-20. The upper limit to the linear range is the maximum signal handling capability of the Input Unit/Preamplifier combination without compression.

3-21. If the 13680 Preamplifier is used, the maximum linear output for less than 0.1 dB compression is +17 dBm. The 13680 exhibits about 45 dB gain. Assuming a nominal mixer conversion loss of 10 dB, the maximum input signal to the mixer is limited to about -18 dBm.

3-22. The AILTECH 13681 Preamplifier has a gain of about 30 dB with the same compression limit as the 13680. For this reason, when the 13681 is used, the upper limit is usually determined by compression effects in the mixer. In general, the compression error caused by a typical mixer will be less than 0.1 dB as long as the signal level is more than 10 dB below the local oscillator input level.

3-23. For most double-ended, unbalanced mixers, using two mixer crystals (such as the AILTECH 135 Series operating above 4 GHz), this sets the maximum signal input at about -7 dBm. For double-balanced mixers, such as the AILTECH 13504 (1-2 GHz) and 13508 (10-1000 MHz), the L.O. drive is +7 dBm, setting the upper limit at approximately -3 dBm.

3-24. Note that the 10 dB safety factor required for noise measurements is not necessary since attenuation or gain measurements are usually made using a CW signal.

CHAPTER IV

THEORY OF OPERATION

4-1. GENERAL

4-2. The AILTECH 13680 and 13681 Preamplifiers (see Schematic Diagram, Figure 5-2) are two-stage tuned amplifiers. The input stage of both units is noise-matched to the typical 30 MHz output impedance of an RF Mixer. Modular, hybrid amplifiers, capable of +17 dBm output with less than 0.1 dB compression are used for the output stages.

4-3. 13680 LOW NOISE PREAMPLIFIER

4-4. Output pins of an Input Unit mate with compressive springs designated J2 and J3. The signals are capacitively coupled via C4 and C5 to the input matching network made up of L5, C6 and L6.

4-5. This network transforms the typical crystal mixer impedance into the optimum source impedance for minimum noise figure of Q1, the first amplifier stage.

4-6. Q1 is a NPN silicon power transistor. The transistor has excellent noise characteristics; thus, it exhibits a low noise figure - important at low input levels, and power handling capability with minimal compressive effects.

4-7. C12, C13, C14, and L8 make up the interstage matching network. This network is also the primary center frequency and bandwidth determining circuit in the Preamplifier. IC1 is a broadband modular hybrid amplifier capable of providing up to +17 dBm into a 50-ohm load with less than 0.1 dB compression.

4-8. Mixer crystal currents pass through J2 and J3.

Filtering is provided to isolate these DC signals from the RF signal path. R1 and R6 are precision resistors used for the crystal current return. They also provide a means of monitoring the crystal currents by means of a DC voltmeter with a conversion factor of 100 mV/mA.

4-9. J4 is a spring clip, similar to the signal inputs, and is also located at the Preamplifier input end. It is used to provide power to the 13635 Converter.

4-10. 13681 WIDE RANGE PREAMPLIFIER

4-11. This unit is a direct adaption of the 13680. The major differences are a biasing change on Q1 to permit handling higher input power levels (with an attendant increase in noise figure), and a lower gain second stage amplifier. Otherwise, the circuit function is identical to the 13680.

CHAPTER V

MAINTENANCE AND ADJUSTMENTS

5-1. GENERAL

5-2. This chapter contains Performance Verification, Adjustments, and Troubleshooting. Schematics and printed circuit board component locations will be found in the Troubleshooting section (Figure 5-2). Spares and replaceable parts are in Chapter VI.

5-3. PERFORMANCE VERIFICATION

5-4. The following procedures, recommended at annual intervals, are designed to insure the user that his AILTECH 13680 or 13681 is operating within specifications. Only those specifications critical to performance are checked. In some cases, more than one specification is verified by the same procedure. Where a specification is a function of adjustment, reference is made to the paragraph describing that adjustment.

5-5. Table 5-1 lists the test equipment required for performance verification.

TABLE 5-1. TEST EQUIPMENT REQUIRED FOR PERFORMANCE VERIFICATION

Description	Recommended Manufacturer and Model
Signal Generator, 30 MHz, Calibrated output level	Boonton 512
Precision Test Receiver (PTR), 30 MHz	AILTECH 13611
Impedance Adapter	AILTECH 208393

TABLE 5-1. (continued)

Noise Source, 30 MHz, 28 VDC Input	AILTECH 7615
Power Meter with Thermistor Mount	HP435A/8481A

5-6. Center Frequency and Bandwidth. The purpose of this procedure is to insure that the Preamplifier is properly tuned.

a. Assemble the Impedance Adapter to the Preamplifier front end. Connect the Preamplifier power plug to the Preamp Power jack on the AILTECH 13611 PTR.

b. Apply power to the signal generator and the power meter. Allow these instruments to stabilize in accordance with the manufacturers' recommendations.

c. Set the signal generator frequency to 30 MHz. Set the output level to:

1. -45 dBm for the 13680

2. -30 dBm for the 13681

d. Connect the equipment as follows:

1. Signal generator output to Impedance Adapter Input

2. Preamplifier output to power meter input

e. Adjust the signal generator output for 0 dBm (1 mW) indication on the power meter.

f. Set the signal generator frequency first, to 28.5 MHz, then to 31.5 MHz. Make certain the generator output level remains constant if the generator is not self-leveled. Note that the power meter indication is greater than -3 dBm (0.5 mW) at both frequency settings.

A gross failure of this check indicates failure of one or both active amplifiers, or a mechanical connection break. Refer to Section 5-17 for troubleshooting information. If the Preamplifier almost passes the check, the unit may simply be in need of realignment. Refer to Section 5-9.

5-7. Gain. This procedure checks general overall operation,

and insures proper alignment.

a. Leave the Preamplifier input connections as in paragraph 5-6. Make the following additional connections:

   1. Preamplifier Output to Attenuator Input on the 13611.

   2. Attenuator Output to IF Input (both on the 13611).

b. Set the signal generator output frequency to 30 MHz.

c. Set the signal generator output level to:

   1. -50 dBm for the 13680

   2. -35 dBm for the 13681

d. Set the 13611 controls as follows:

   1. MODE switch - DET position

   2. DET switch - NORM position

   3. ATTENUATION - 50.0 dB reading

   4. COARSE and FINE GAIN - Adjust for an on-scale reference indication on the meter.

e. Without disturbing any controls, connect the signal generator output directly to the ATTENUATOR Input.

f. Decrease the 13611 ATTENUATION control until the meter returns to the reference set in Step d (4). Note that the ATTENUATION readout indicates:

   1. < 5 dB for the 13680

   2. < 20 dB for the 13681

A gross failure of this test indicates failure of one or both active amplifier stages, or a mechanical connection break. Refer to Section 5-17 for troubleshooting information. If the gain test fails by just a few dB, the unit may simply be in need of realignment. Refer to Section 5-7.

5-8. Noise Figure. Refer to the 13611 Instruction Manual for the setup and procedures for a 30 MHz noise figure measurement

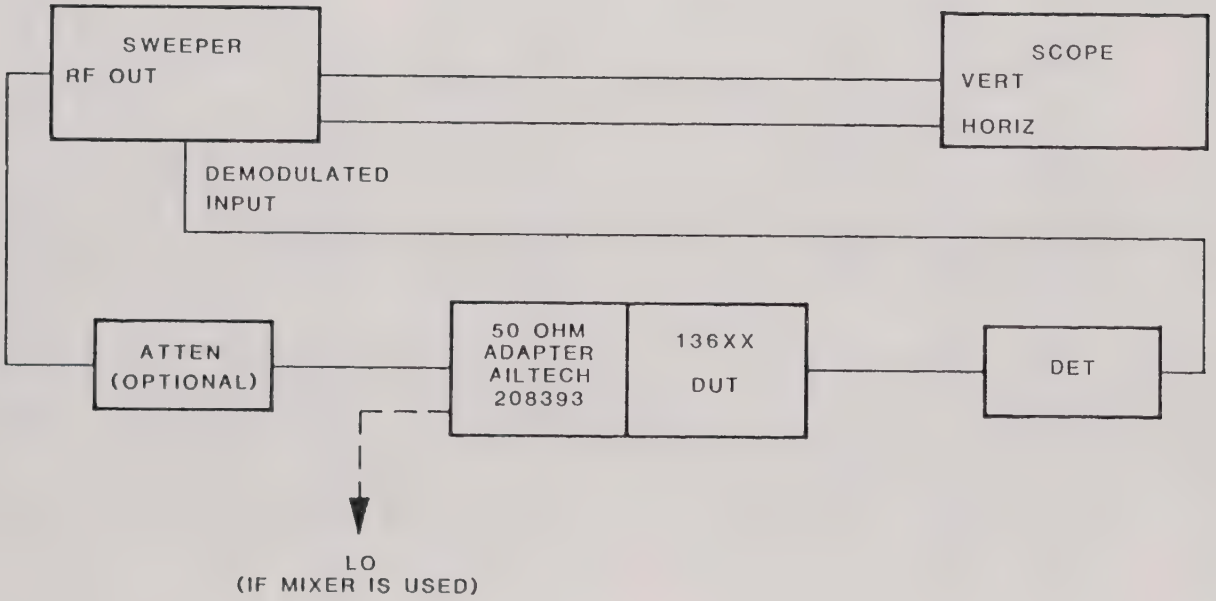


FIGURE 5-1. TYPICAL SWEPT ALIGNMENT SETUP

5-17. TROUBLESHOOTING INFORMATION

5-18. The Preamplifiers are quite sensitive (high gain and compression point, and low noise figure). Stable operation requires a tight mechanical structure with excellent continuous grounding. The assembled Preamplifier is, consequently, difficult to assemble and disassemble, except by experienced personnel. For this reason, it is recommended that the units be returned to the factory (see Section 5-28) for maintenance, in the event of a serious specification failure or catastrophic malfunction. If return to the factory is difficult or inconvenient, the following considerations should be of assistance in isolating the cause of the failure.

5-19. The circuit design of the Preamplifiers is relatively simple, and a competent service technician should have no difficulty isolating faulty components using standard signal tracing techniques and voltage measurements (see schematic diagram for voltage charts).

5-20. The Preamplifier consists of a single printed circuit board assembly rigidly held by spring finger contact strips between two L-shaped, interlocking, aluminum extrusions. The entire assembly is locked together by the end-plate at the output end, and the Input Unit. These are secured by screws mating with threaded inserts in the extrusion ends.

5-21. Before disassembling the Preamplifier, disconnect the power plug from the power source, remove the Input Unit, and make the following checks:

a. Place a straightedge across the front edges of the extrusions, and make certain that the three spring clips at the input end are recessed about 1/16 inch (1.6 mm) from the plane of the extrusion ends. If these clips extend too far forward, they could be short circuited to ground by the Input Unit. This could cause a number of apparent malfunctions, including total or intermittent loss of signal, and loss of DC power. If this condition occurs, it will be necessary to disassemble the Preamplifier (see paragraph 5-23), and reposition the PC board.

b. Using a DC ohmmeter, check the resistance from the pins on P1, the power plug, as indicated in Table 5-2.

TABLE 5-2. POWER PLUG RESISTANCE CHECK

From P1 Pin #	To	Resistance (ohms)
1	Case	C
2	J4	100
3	Case	0
4	Case	∞
5	J2	0
5	J3	200
5	Case	100
6	J2	200
6	J3	0
6	Case	100

Failure of one or more of these resistance checks usually indicates a circuit break in P1, at the test point solder connections at the rear of the PC board, or in a PC board trace. If the break occurs at the test point solder joint, it may be possible to repair it simply by removing the end plate (secured by four screws at the rear of the case), and resoldering the joint without completely disassembling the Preamplifier case.

5-22. If the problem cannot be solved by any of the preceding methods, it will be necessary to disassemble the Preamplifier, and troubleshoot the PC board. The simplicity of the circuit design makes detailed malfunction flow charts unnecessary. In general, a significant gain loss (usually accompanied by a sizeable increase in noise figure) will be a result of failure of one or both active amplifiers - Q1 or IC1. The voltage charts provided (see schematic diagram, Figure 5-2) should be of considerable assistance in isolating the faulty component.

5-23. DISASSEMBLING THE PREAMPLIFIER

5-24. The general construction of the Preamplifier is outlined in paragraph 5-20. In order to provide full access to the PC board assembly, it is necessary to force the two extruded halves apart. Considerable force will be required due to the pressure exerted by the contact springs which extend the length of the case.

a. Disconnect the Preamplifier power plug, P1, from the power source.

b. Remove the Input Unit (four screws at the input end of the Preamplifier).

c. Remove the four screws holding the end plate to the rear of the case. Gently, pull the end plate away from the case to extend the internal connecting wires and expose the extrusions' ends.

d. (Also see paragraph e below.) In any of the four corners where a horizontal surface of an extrusion is mated to a channel in a vertical surface (two each, front and rear), insert a small-bladed screwdriver, or other small, suitable prying instrument, and GENTLY force the two halves of the case apart until they separate completely. Note that the PC board will remain with the lower half.

e. Alternatively, a pair of pliers with padded jaws, can be inserted into the input end. Steady outward pressure on the handles will force the two extrusion halves apart.

5-25. REASSEMBLING THE PREAMPLIFIER

5-26. Reassembling the Preamplifier requires some care to insure that:

a. The extrusions and the contact strips are properly aligned so that, when mated, the end surfaces are flat.

b. The PC board assembly is recessed about 1/16 inch from the front surface (see paragraph 5-21 a).

5-27. Once the mechanical components are properly aligned, the two case halves may be squeezed together until fully mated.

A bench vise with padded jaws to protect the case surface may be used for this purpose. Use only as much pressure as necessary to mate the extrusions. Too much force can permanently distort the case or crack the PC board.

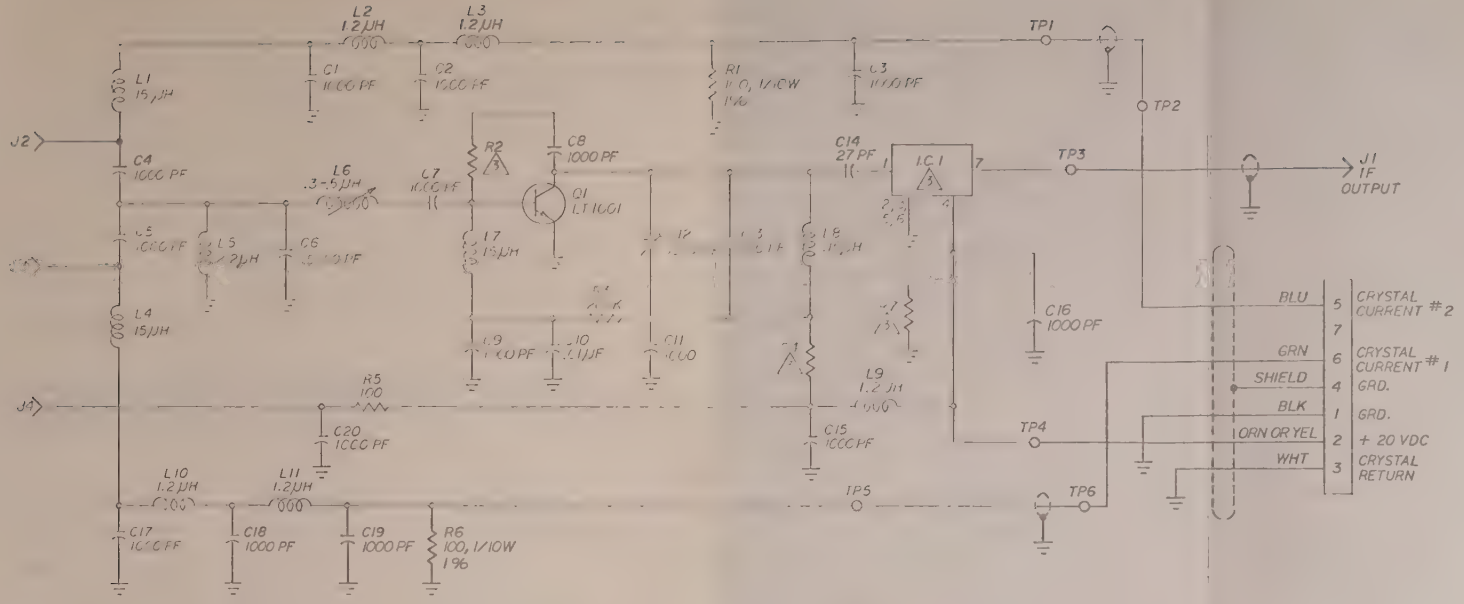
5-28. FACTORY SERVICE

5-29. In the event a difficult service problem occurs, contact your nearest Eaton Corporation Regional Office or Sales Representative by letter, TWX or phone. Please indicate the model number, serial number, and specific details of the difficulty involved, with as much additional information as considered necessary to aid in pinpointing the cure to the problem.

5-30. Should it be necessary to return the equipment to the factory for repair or calibration, please contact Eaton Corporation or an authorized sales representative in your area before shipping a unit. In your communication arranging for a return, please be sure to include model number, serial number, date of purchase, and the specific details concerning the problem (in the event of failure) or service desired (in the event of recalibration).

5-31. When an instrument is returned for service, we will proceed to work on the instrument until the charges reach $100. If the total charges exceed $100, an estimate of such charges will be submitted for approval.

5-32. When spare parts are ordered, please indicate a description of the part as well as its part number, and also include the model number of the instrument to be repaired.



GND TP7-12

SYMBOL	COMMON NAME	
NO	13680	13681
IC 1	CA3810	CA 3118
R 2	1.5K	5.0Ω
R 4	1.1K	300Ω
R 7	NOT USED	300Ω, 5W

VOLTAGE* CHART		
TEST POINT	13680	13681
TP4	+ 20	+ 20
EMITTER JCT	+ 0.6	+ 16
BASE Q1	+ 0.7	+ 0.7

* ALL VOLTAGES WITH RESPECT TO GROUND (CASE), TAKEN WITH A HIGH IMPEDENCE DIGITAL VOLTMETER (DVM) WITH THE MEASUREMENT PROBE ISOLATED FROM THE TEST POINTS BY A SERIES 1K RESISTOR.

R7 INSTALLED ONLY ON 13681 ASSEMBLIES

FIGURE 5-2. SCHEMATIC DIAGRAM AND COMPONENT LAYOUT, AILTECH 13680 AND 13681 PREAMPLIFIERS

CHAPTER VI

SPARE PARTS

6-1. RECOMMENDED SPARES

6-2. Based on reliability and maintainability aspects of design, the following spares are recommended to support a small quantity of 13680 or 13681 Preamplifiers.

Symbol	Description	Manufacturer	Part Number	Notes
C6, C12	Capacitor, Var.	Erie	538-011F-15-60	-
IC1	Amplifier, CATV	TRW	CA2810	1
IC1	Amplifier, CATV	TRW	CA2818	2
L6	Inductor, Var.	Caddell-Burns	C-B-435-1	-
Q1	Transistor	TRW	LT1001	-

Notes: 1. 13680 only

2. 13681 only

6-3. REPLACEABLE PARTS

Symbol	Description	Manufacturer	Part Number	Notes
C1,2,3,4, 5,7,8,9, 11,15,16, 17,18,19,20	Capacitor, 1000pF	Centralab	DD102	-
C6,12	Cap., Var., 15-60 pF	Erie	538-011F-15-60	-
C10	Cap., 0.01 µF	---	CK63AW103M	-
C13	Cap., 180 pF	Elmenco	DM10-181J	-
C14	Cap., 27 pF	Elmenco	DM10-270J	-
IC1	Amplifier, CATV	TRW	CA2810	1
IC1	Amplifier, CATV	TRW	CA2818	2
J1	Connector, BNC, Female	---	UG-625/U	-
L1,4,7	Inductor, 15 µH	Delevan	1840-34	-
L2,3,9, 10,11	Inductor, 1.2 µH	Delevan	1840-11	-
L5	Inductor, 2.2 µH	Delevan	1840-14	-
L6	Inductor, Var., 0.3-0.5 µH	Caddell-Burns	C-B-435-1	-
L8	Inductor, 0.15 µH	Nytronics	WEE-.15	-
Q1	Transistor	TRW	LT1001	-
R1,6	Res., 100Ω, 1/10 W, 1%	---	RN55C1000F	-
R2	Res., 1.5 kΩ, 1/4 W, 5%	---	RC07GF152J	1
R2	Res., 510Ω, 1/4 W, 5%	---	RC07GF511J	2

6-3. REPLACEABLE PARTS (continued)

Symbol	Description	Manufacturer	Part Number	Notes
R4	Res., 1.6 kΩ, 1/4 W, 5%	---	RC07GF162J	1
R4	Res., 360 Ω, 1/4 W, 5%	---	RC07GF361J	2
R5	Res., 100 Ω, 1/4 W, 5%	---	RC07GF101J	-
R7	Res., 300 Ω, 5W	Sprague	243E3015	2

Notes: 1. 13680 only

2. 13681 only

APPENDIX A

CALCULATION OF NOISE LEVELS IN AMPLIFIERS

A-1. INTRODUCTION

A-1.1. Noise levels in an amplifier or amplifier cascade can be calculated from a knowledge of the amplifier noise figure, gain, bandwidth, and temperature of the input termination. Some assumptions are necessary, but the results are a close enough approximation for most practical situations.

A-2. THERMAL NOISE

A-2.1. Noise in receivers and amplifiers (transducers) is characterized in terms of the electrical noise power available at the terminals of a resistive termination in a specific thermal environment:

$$N = kTB \qquad \text{(A-1)}$$

where, N = available noise power

k = Boltzmann's Constant (1.38×10^{-23} joules/kelvin)

T = temperature on the absolute scale (kelvins)

B = bandwidth

A-2.2. The noise power available from a resistive termination at the standard reference temperature T_o (290K), observed through a 1 MHz band would then be:

$$N = (1.38)\ (10^{-23})\ (290)\ (10^{6})$$

$$= 4 \times 10^{-15} \text{W or } 4 \times 10^{-12} \text{ mW}$$

If this is expressed in dB relative to a milliwatt (dBm):

$$N_{dBm} = -114 \text{ dBm}$$

A-2.3. If the bandwidth is other than 1 MHz, then to calculate the available noise output, it is only necessary to add:

$$10\text{Log}_{10}B \text{ (MHz)} \qquad \text{(A-2)}$$

to the reference noise in dBm. For example: If the bandwidth is 10 MHz, then,

$$N_{dBm} = -104 \text{ dBm}$$

A-3. NOISE FIGURE

A-3.1. Noise figure, in simplified form, can be defined as the ratio of the actual noise output of a transducer to that of an ideal, noiseless transducer of otherwise identical characteristics whose input termination is at the standard reference temperature, T_o.

$$F = \frac{N_o}{kT_oBG} \qquad \text{(A-3)}$$

where, N_o = noise power available at the transducer output

G = available gain of the transducer

A-3.2. Equation (A-3) can be rewritten:

$$N_o = FkT_oBG \qquad \text{(A-4)}$$

If Equation (A-4) is expressed in dB, the transducer output noise power can be calculated quite simply from:

$$N_{o(dBm)} = (-114) + F_{dB} + G_{dB} + 10\text{Log}_{10}B\text{(MHz)} \qquad \text{(A-5)}$$

The equivalent input noise is simply:

$$N_i = \frac{N_o}{G} = FkT_oB \qquad \text{(A-6)}$$

and,

$$N_{i_{(dBm)}} = (-114) + F_{dB} + 10Log_{10}B_{(MHz)} \qquad (A\text{-}7)$$

A-4. APPLICATION TO THE AILTECH 75 PANFI

A-4.1. The sensitivity of the PANFI is defined as the minimum noise level at which valid noise figure indications can be obtained. For a standard, 30 MHz instrument, this is specified as -76 dBm.

A-4.2. If the measurement system consists of a PANFI preceded by a 13680 Preamplifier with 45 dB gain, the sensitivity of the combination in the absence of measurement system noise, would be -121 dBm. However, the noise output of the device-under-test (DUT) must be at least as large as the noise level at the Preamplifier input for minimally meaningful measurements.

A-4.3. The bandwidth of the Preamplifiers is approximately 3 MHz, and the typical noise figure is 3.3 dB. Applying Equation (A-7):

$$N_i = (-114) + 3.3 + 10Log_{10}3$$

yields a noise level of about -106 dBm. This, then, is considered the lower limit of the measurement range (sensitivity) of the Preamplifier/PANFI combination. Note that the Preamplifier bandwidth is used for the calculation since it is less than that of the PANFI.

A-4.4. Applying these same considerations to the 13681 (6 dB typical noise figure) yields a lower limit of about -103 dBm.

AEB 135-1

September 1976

REPLACEMENT DIODES FOR THE 135 SERIES MIXERS

The following is a list of diodes used in the AILTECH 135 Series balanced mixers operating from 2 to 38 GHz. The 13508 Mixer (0.01 to 1 GHz) and the 13504 (1 to 2 GHz) use double-balanced diode quads, and are not considered field replaceable.

Mixer P/N	Frequency Range	Diode P/N's
13505	2 to 4 GHz	1N416E
13506	4 to 8 GHz	1N23E/ER
13507	7 to 11 GHz	MA492E/ER
13509	3.6 to 4.2 GHz	1N416E
13546	8.2 to 12.4 GHz	MA4900E/ER
13547	12.4 to 18 GHz	MA4901E/ER
13553	18 to 26.5 GHz	MA4902BMRS
13596	26.5 to 38 GHz	MA4903CMRS

Those diodes with part numbers beginning with the letters "MA-" are manufactured by Microwave Associates of Burlington, MA. The other diodes on the list are also available from Microwave Associates as well as other semiconductor manufacturers.

Alternatively, replacement diodes may be ordered from AILTECH. Consult AILTECH West for price and delivery details.

William E. Pastori
Product Line Manager
Noise Products

WEP:hk

APRIL 1979

OPERATION OF THE AILTECH 135 SERIES MIXERS

I. The 135 Series Mixers are designed to plug-in and operate with the AILTECH 136 Series Preamplifiers. The I.F. outputs are via pins which mate with spring clips at the Preamplifier inputs. Because of this, they must be operated in conjunction with a 13630, 13650, 13680, or 13681.

Since these devices are accessories to our instrument line, used to downconvert RF and microwave frequencies to the 30 MHz intermediate frequency of the preamplifiers, applicable specifications consist only of their individual frequency ranges (listed in the Noise Instrumentation Catalog).

II. Three types of mixers are represented in the 135 Series:

A. At lower frequencies (below 2 GHz), the mixers are of the doubly-balanced configuration utilizing four diodes in a bridge configuration. These are identifiable by the fact that they have only one output pin.

B. Between 2 GHz and 11 GHz, the mixers are of the coaxial, hybrid, double-ended, unbalanced configuration utilizing two diodes one of which is reversed, so that the I.F. signals at the two output pins are in phase.

C. Above 8.2 GHz, most mixers are in a waveguide ortho-tee configuration, and are also double-ended, unbalanced.

The following list identifies the three types by part number.

FREQUENCY RANGE	P/N	TYPE*	LO/RF CONNECTORS
0.01 - 1 GHz	13508	A	TNC
1 - 2 GHz	13504	A	TNC
2 - 4 GHz	13505	B	N
3.6 - 4.2 GHz	13509	B	N
4 - 8 GHz	13506	B	N
7 - 11 GHz	13507	B	N
8.2 - 12.4 GHz	13546	C	WR-90 Cover flange
12.4 - 18 GHz	13547	C	WR-62 Cover flange
18 - 26.5 GHz	13553	C	WR-42 Cover flange
26.5 - 38 GHz	13596	C	WR-28 Cover flange

*Reference preceeding paragraphs.

III. The mixers are designed to bolt on to the front end of a 136 Series Preamplifier (mounting hardware is provided with the Preamplifier). Power is provided to the Preamplifier via an integral cable by a 13610 Precision Test Receiver, 75 PANFI or an appropriate external power supply (pin connections for the Preamplifier are detailed in the 13610 Instruction Manual).

Local oscillator power is applied to the L.O. port of Type A mixers or to either port of Types B and C. The 13610 Receiver provides a means of monitoring L.O. drive of Types B and C mixers by means of a meter readout of rectified crystal current. The nominal crystal current of Types B and C is 1 mA in each crystal. Typically, this requires between 0 and +3 dBm of L.O. drive (1 to 2 mw).

In some mixers (Types B and C) it may not be possible to achieve exactly 1 mA in both crystals simultaneously. This is due to external mismatch, internal reflections, etc. A three-to-one ratio of currents is considered acceptable; i.e., one crystal operating at 0.5 mA, the other at 1.5 mA. These mixers should never be operated at greater than 3 mA crystal current.

If the balance condition above cannot be met, it is usually due to one of two conditions:

A. A poor VSWR at one or both input ports (both ports must be terminated properly).

B. A bad crystal (Reference AEB 135-1 for a listing of replacement crystals).

There is no provision for monitoring crystal current in Types B and C mixers when the AILTECH 75 PANFI is used as the power source for the Preamplifier; however, external voltmeters can be used for this purpose. Pins 5 and 6 on the Preamplifier power connector provide voltages proportional to crystal current (100 mV per mA). Pin 3 is the return.

The crystal returns in Type A mixers is internal to the mixer, and no crystal current will be observed on a 13610 or external meter. These mixers should be driven at about +7 dBm L.O. power (5 mw). The L.O. drive is not critical and may be adjusted for best mixer performance (noise figure, for example). The drive should, however, not exceed +10 dBm.

William E. Pastori

William E. Pastori, Product Line Manager, Noise Products

WEP/kaf

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